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I. Introduction

In response to the Office Action dated October 11, 2006, please consider the following amendments and remarks. Re-examination and re-consideration of the application, as amended, is requested.

II. Allowable Subject Matter

In paragraph 11, the Office Action indicates that the subject matter of claims 4, 9, 10, 15, 20, 21, 26, 31, and 32 would be allowable if written in independent form including all of the limitations of the base claim and any intervening claims. The Applicants acknowledge the Office Action's indication of allowable subject matter, but traverse the rejection of claims 1-3, 5-8, 11-14, 16-19, 22-25, 27-30 and 33. Should the rejection of these claims be maintained, the Applicants will make suitable amendments to present the allowable claims in independent form.

III. The Cited References and the Subject Invention

## A. The Basuthakur Reference

U.S. Patent No. 6,003,817, issued December 21, 1999 to Basuthakur et al. disclose an actively controlled thermal panel and method therefor. One or more deployable thermal panels (24, 28, 70) are actively controlled throughout the orbit of a satellite (20) to provide thermal dissipation. Adjusting the incident angle between the panel (24, 28, 70) and the sun and controlling the flow of fluid through optional flexible heat pipes loads and unloads heat to provide thermal stability for components (62) which have special thermal requirements. An optional antenna panel (70) on a nadir side (64) of the satellite (20) offers an antenna side (74) on one surface and a thermal radiating side (72) on an opposing surface. In addition, thermal panel movements are controlled (96) to provide counter-disturbance torques (140).

## B. The Kazimi Reference

U.S. Patent No. 6,311,929, issued November 6, 2001 to Kazimi et al. disclose spacecraft and appendage stepping methods that improve spacecraft attitude pointing and cancel solar array slew

disturbances. A spacecraft having a body, one or more appendages coupled thereto, and a controller that implements methods that rotate the one or more flexible appendages to point it (them) towards the Sun to reduce spacecraft attitude pointing disturbances and improves spacecraft attitude pointing. The steps of the one or more appendages are timed to deadbeat the disturbance imparted to the spacecraft body. Timing of the appendage steps may be such that the periodic disturbances are phased to substantially cancel each other, or phased to decrease the magnitude of the net disturbance. The present invention also cancels solar array slew disturbances. The present invention cancels predictable disturbance torques before they produce a pointing error, improving the spacecraft pointing performance. The present invention predicts a disturbance torque exerted on the body due to the controller moving the one or more appendages, calculates a feedforward torque necessary for the controller to cancel the disturbance torque and includes the feedforward torque in the calculation of the total control torque applied to the body.

#### IV. Office Action Prior Art Rejections

In paragraph (2), the Office Action rejected claims 1, 2, 12, 13, 23, and 24 under 35 U.S.C. § 102(b) as being anticipated by Basuthakur et al., U.S. Patent No. 6,003,817 (Basuthakur). The Applicants respectfully traverse this rejection.

With Respect to Claim 1, 12, and 23: Claim 1 recites:

*A method of controlling a plurality of solar panels coupled to a spacecraft, comprising the steps of: providing a first step command to a first solar panel; and providing a second step command to a second solar panel at a time of a transient zero-crossing of a dynamic response of the spacecraft body to the first step command; wherein the second solar panel is disposed on an opposite side of the spacecraft from the first solar panel.*

The Office Action suggests that the foregoing features are disclosed in the following excerpt from the Basuthakur reference:

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After task 118, a task 120 estimates and stores the counter-disturbance torque. The counter-disturbance torque is calculated to oppose the disturbance torques satellite 20 is currently experiencing as determined above in task 118. Like disturbance torque, the counter-disturbance torque has components in the windmill axis, the overturning axis, and pitch axis, but the counter-disturbance torque is in an opposing direction to a disturbance torque. Disturbance torques can have directional components in each of the windmill axis, overturning axis, and pitch axis. A combined disturbance torque is the vector sum of disturbance torques in all three axes. The counter-disturbance torque is a torque having a direction and having components in up to all three axes. However, the counter-disturbance torque has a direction, discussed later in relation to FIG. 7, which opposes the direction of the combined disturbance torque.

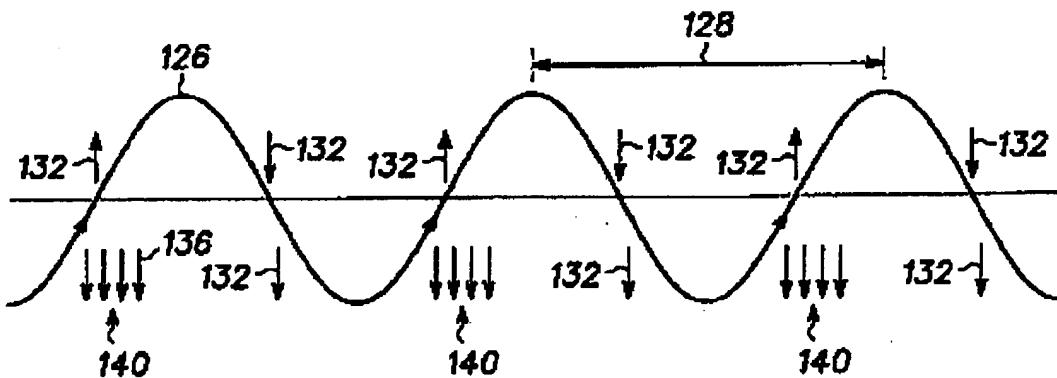
After task 120, a task 122 determines and stores panel movements that will achieve the counter-disturbance torque as determined above in task 120. Task 122 determines panel movements within stored constraints. The constraints come from thermal control process 94 (FIGS. 4 and 5) and represent limits to panel movement and valve adjustment that can occur without hindering thermal control. The constraints depend on orbit position. In a typical scenario, the one of thermal panels 24 and 28 which opposes the sun is not constrained in movement as is the other of thermal panels 24 and 28 which faces the sun.

Desirably, task 122 accounts for substantially all torque components in all three axes produced directly and indirectly from the determined panel tilt and pivot so that the

resultant torque vector sum of all such direct and indirect torques is the desired counter-disturbance torque.

Upon completion of task 122, process flow loops back to task 114. The looping of process flow indicates that process 96 continuously performs tasks 114, 118, 120 and 122 in the preferred embodiments throughout the on-orbit life of satellite 20.

And in FIG. 7 which is reproduced below:



**FIG. 7**

The foregoing describes a system that uses sensor measurements of satellite motion to estimate which disturbance torques could have caused satellite motion (task 118). The system (task 120) then calculates counter disturbance torque to oppose the disturbance torques the satellite is

now experiencing. The counter disturbance torque will generally be a vector sum of torque components in three directions. FIG. 7 shows that the direction (136) of the counter-disturbance torque pulses (140) is chosen to oppose the estimated disturbance torques (application of the opposing counter-disturbance torque pulses is delayed until the direction (136) of the counter disturbance torques 140 oppose the nutation direction (132)).

The foregoing fails to teach a number of features recited in claim 1, namely: (1) Basuthakur does not apply a second *step* command at a zero crossing. FIG. 7 illustrates a train of *pulses*, none of which are applied at the zero crossing point; and (2) Basuthakur does not teach providing a second step at to a solar panel disposed on an opposite side of the spacecraft from the solar panel to which the first pulse was applied. Instead, Basuthakur teaches estimating a disturbance torque (caused by solar wind and other factors) and using both of the solar panels to attempt to oppose the disturbance torque.

Hence, Basuthakur does not teach the features of claim 1, and the Applicants respectfully traverse the rejection of claim 1.

Claims 12 and 23 recite analogous features and are patentable for analogous reasons.

Dependent claims 2-11, 13-22, and 24-33 each recite the features of claims 1, 12, and 23, respectively, and are patentable on this basis.

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In paragraph (5), the Office Action rejected claims 1, 3, 5-8, 11, 12, 14, 16-19, 22, 23, 25, 27-30, and 33 under 35 U.S.C. §102(b) as being anticipated by Kazimi et al., U.S. Patent No. 6,311,929 (Kazimi). The Applicants respectfully traverse this rejection.

With Respect to Claims 1, 12, and 23: The referenced portion of Kazimi:

Referring to the drawing figures, FIG. 1 illustrates an exemplary spacecraft 10 in which the present methods may be employed. The spacecraft 10 comprises a body 11 having rotatable North and South solar array wings 12, 13 coupled thereto. A servo controlled stepping mechanisms 14 such as a stepping motor and an appropriate gear train is coupled to the North and South solar array wings 12, 13. A controller (CONTROLLER) 15 is coupled to the servo controlled stepping mechanisms 14 which cooperate to rotate the North and South solar array wings 12, 13 to point them towards the sun. The North and South solar array wings 12, 13 are rotated on a stepwise basis using the controller 14 in a manner provided by the present invention.

In general, the North and South solar array wings 12, 13 are stepped at a rate required for sun tracking. Previous designs developed by the assignee of the present invention have equally spaced the North and South wing steps so that the disturbance to the spacecraft body 11 is equally spaced. However, this does not minimize the disturbance to the spacecraft 10.

discloses a system in which the opposing solar panels are dead-beated so that the periodic signals from the North and South wings cancel one another (their phases are 180 degrees apart). While effective, this deadbeat system has disadvantages. As described in the Applicant's specification:

Another technique is described in co-pending and commonly-assigned patent Application Serial No. 10/386,796, entitled "METHOD AND APPARATUS FOR STEPPING SPACECRAFT MECHANISMS AT LOW DISTURBANCE RATES," by Ketao Liu, filed on March 12, 2003, attorney's docket number PD-02-0237, in which transients due to the interaction between appendage stepping and resonances are reduced by deadbeating at a half resonance cycle between the North and South wings. This technique, however, is subject to frequency sensitivities and uncertainties, and cannot be implemented in all existing spacecraft.

In other words, while simple deadbeating technique is effective, it relies on good estimates for the resonant frequencies, and is therefore cumbersome to implement. The Kazimi reference itself alludes to this problem, and suggests that the computations required to estimate these factors be performed on the ground and later uplinked to the satellite:

The present invention provides for a period between the North and the South wing steps that deadbeats the flexible appendage disturbance imparted to the spacecraft body 11 by the North and South solar array wings 12, 13. The term "deadbeat" as used herein means to make two periodic signals cancel each other by ensuring they have phases 180 degrees apart, which makes the two signals be the negative of each other and causing their sum to go to zero. In practice, so such perfect cancellation is not generally possible since the phases and magnitudes will vary slightly. The practical definition of deadbeating is that the two signals substantially cancel each other, decreasing the magnitude of the sum of the two signals. The term "deadbeat interval" refers to the delay between the two signals. The two signals deadbeat each other when their deadbeat interval is half the period of

the signals, making the two signals be the negative of each other and making the sum of the two signals be substantially zero.

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5 The present invention causes the deadbeat interval or period to be less than the step rate required for sun tracking. In this way spacecraft attitude pointing is improved without requiring any change to the sun tracking rate of each individual wing 12, 13. In addition, the timing between the first and second appendage steps can be ground commanded 10 so that uncertainties in the flexible properties of the appendages (solar array wings 12, 13) can be optimized easily while the spacecraft 10 is on-orbit.

The Applicant's invention avoids this problem by providing the second step command at the transient zero-crossing time of the dynamic response of the spacecraft body to the first step command. This technique, which is not disclosed in Kazimi, is not subject to frequency sensitivities and uncertainties, does not require computations to be performed on the ground and later uplinked, and can be implemented in all spacecraft.

Claims 12 and 23 recite analogous features and are patentable for analogous reasons.

V. Dependent Claims

Dependent claims 2-10, 13-22, and 24-33 incorporate the limitations of their related independent claims, and are therefore patentable on this basis. In addition, these claims recite novel elements even more remote from the cited references. Accordingly, the Applicants respectfully request that these claims be allowed as well.

VI. Conclusion

In view of the above, it is submitted that this application is now in good order for allowance and such allowance is respectfully solicited. Should the Examiner believe minor matters still remain that can be resolved in a telephone interview, the Examiner is urged to call Applicants' undersigned attorney.

Respectfully submitted,

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